

# Design of Intelligent Dustbin System based on Internet of Things

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## Abstract

At present, the concept of garbage classification is weak and the distribution of garbage cans is uneven, which makes it difficult to implement the garbage classification policy. This paper designs an intelligent garbage can system based on the Internet of things. The intelligent trash can classify the garbage thrown by the user through voice recognition and open the corresponding trash can. The residual capacity, temperature and humidity, whether it is on fire and other information of the trash cans can be detected through multiple sensors. These information is uploaded to the upper computer software through wireless transmission. The upper computer reminds the cleaning personnel to clean up in time by processing and saving the data sent by the intelligent trash can. The intelligent trash can system can reduce the user's learning of garbage classification knowledge, improve garbage classification efficiency, improve the utilization rate of trash cans, and reduce the workload of garbage cleaners, It puts forward a feasible scheme for urban environmental protection.

## Keywords

Intelligent Dustbin; Sensor; Voice Recognition; Wireless Transmission.

## 1. Introduction

On July 1, 2019, Shanghai officially implemented the Regulations on the Management of Domestic Waste in Shanghai, making it the first city in China to comprehensively enforce garbage classification. All over the country, garbage classification has been carried out. From the initial media publicity to the present, the effect of garbage classification is also unsatisfactory [1]. After analysis, the main reasons are as follows: first, because of the lack of attention on classified garbage education in the previous period, many people don't know how to classify garbage; second, the proportion of classified garbage bin is unbalanced, for example, the amount of kitchen waste is the largest, sometimes the garbage bin is full, people can only throw the separated garbage into other dustbins; third, the cleaning up of the garbage cleaners is not timely. When you cannot know which dustbin is full or not, the method to be taken is to clean it one by one, which makes the use of the dustbin inefficient and the cleaning efficiency of the cleaners inefficient.

To solve the above problems, this paper designs an intelligent trash can system based on the Internet of Things [2]. The smart trash can classify the trash thrown by the user by voice recognition, open the corresponding trash can, and detect the remaining capacity, temperature and humidity, is it on fire and other information of the trash can through its own sensors. The information is uploaded to the upper computer software, which reminds the cleaner by processing and saving the data sent from the smart trash can and the intelligent garbage bin system can reduce the learning degree of users on garbage classification knowledge, improve the efficiency of garbage classification, increase the usage of garbage bin, reduce the workload of garbage cleaners, and provide a feasible scheme for urban environmental protection.

## 2. Technical Indicators for Intelligent Dustbin System

The technical indicators of the smart garbage can based on the Internet of Things are as follows:

- (1) The opening and closing of the trash can be controlled by voice;
- (2) Real-time measurement of temperature, humidity, smoke concentration and fire sources situation in the trash can;
- (3) Distance measuring range: 2~150 cm, accuracy: 0.5 cm;
- (4) Temperature range: 0-50 degree Celsius, temperature accuracy: 1 degree Celsius;
- (5) Humidity range: 20-90%RH, accuracy: +5%RH;
- (6) The concentration range is 300~10000 ppm.

The smart trash can transmit the measured information to the upper computer software in time. The upper computer software can monitor more than five smart trash cans at the same time, and display the obtained information on the main interface.

## 3. Overall Functions of Intelligent Dustbin System

The intelligent garbage bin system based on the Internet of Things consists of several smart garbage cans and a host computer software. The specific working principle is as follows:

- a) Smart trash can by voice recognition module [3], a variety of sensor modules, wireless transmission module. The voice module is used to identify the voice to judge the type of garbage, open the corresponding garbage can after recognition is completed; a variety of sensor modules are used to monitor the residual capacity of the garbage can, whether it is on fire and other environmental information; the wireless transmission module is to send the data monitored by the sensor to the upper computer software.
- b) The upper computer software processes and saves the received data, displays the data in the upper computer interface, and makes it easy for managers to see. If the garbage can is full or other abnormal conditions, the upper computer software will automatically alarm and alert cleaners to handle.

The overall functional block diagram of the system is shown in Figure 1.

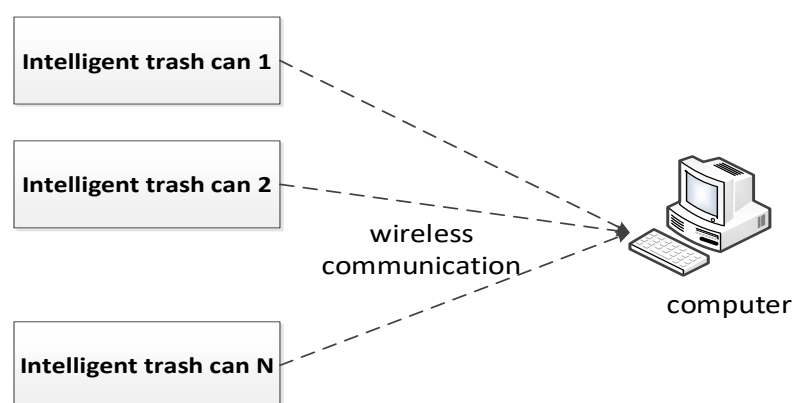


Figure 1. Overall functional block diagram of intelligent trash can system

## 4. Hardware design of intelligent trash can

The smart trash can is composed of CPU module, voice recognition module, ultrasonic distance measuring module, flame detection module, temperature and humidity detection module, smoke monitoring module, dial switch module, motor drive module and wireless transmission module. Figure 2 is the hardware block diagram of the smart trash can.

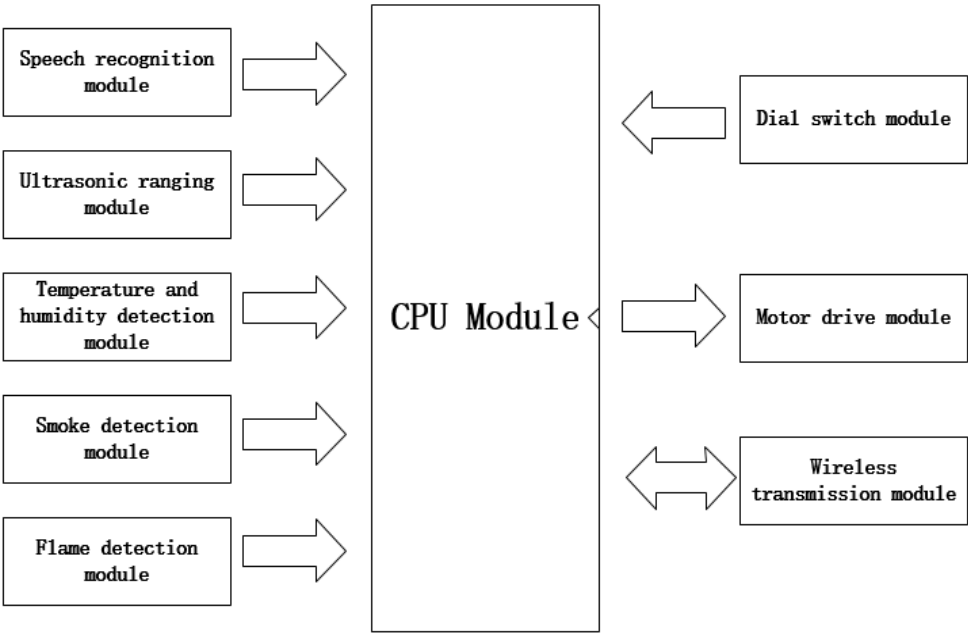


Figure 2. Hardware block diagram of intelligent trash can

4.1. Wireless transmission module

The wireless transmission module adopts nRF24L01 + PA + LNA, 1100 meter long-distance transmitting and receiving module. The wireless transmission module is installed at the intelligent trash can and the host computer software master computer for data communication between the intelligent trash can and the host computer software.

The wireless communication module is a single-chip wireless transceiver chip, which uses SPI protocol. The built-in modem nRF24L01 has six channels, and each channel can receive data. The mutual communication between two nRF24L01 needs to meet the following four conditions: the first is that the channel is the same (0 ~ 125), the second is that the address is the same (the number of address bytes is 5), the third is that the number of bytes sent and received each time is the same (the maximum is 32 bytes), and the fourth is that the transmission and reception rate should be the same (2M, 1M, 250K). Data can be correctly received only when the sending address, response signal address (channel) and receiving address are the same.

By viewing the official data manual, nRF24L01 module can only use channel 0 to realize many-to-one communication by changing the address and channel. It can meet the wireless communication function of intelligent trash can.

The wireless transmission module nRF24L01 can transmit data through the SPI interface. Therefore, the SPI2 function of stm32f103c8t6 is used in this paper. The circuit connection diagram of the wireless transmission module nRF24L01 is shown in Figure 3.

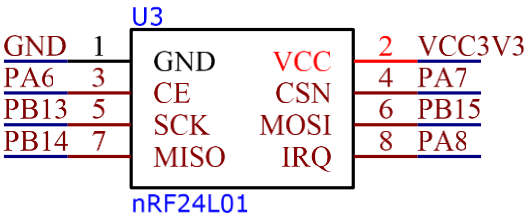


Figure 3. Circuit connection diagram of wireless transmission module nRF24L01

## 4.2. Ultrasonic ranging module

The intelligent trash can detects the amount of garbage in the trash can by ultrasonic module detection. The ultrasonic sensor measures the distance from the garbage in the trash can to the top in real time and sends the data to the upper computer. After data processing, the remaining capacity in the trash can will be displayed intuitively. If the distance is 0cm, it means that the trash can is full. Hc-sr04 is selected as the ultrasonic ranging module in the intelligent trash can. The measurable range of hc-sr04 ultrasonic ranging module is 2cm ~400cm, and the measurement distance accuracy can reach 3mm. The module integrates ultrasonic transmitter, receiver and control circuit. The module uses the reflection of ultrasonic after contacting the object to realize the non-contact ranging function.

According to the circuit signal flow chart provided in the data manual, the pb5 pin of the main control chip is connected to the trig pin of the ultrasonic module, and the pb6 pin is connected to the echo pin of the ultrasonic module. Pb5 sends a high-level signal to trigger ranging, the ultrasonic module sends ultrasonic, and automatically detects whether there is a signal return. If a signal returns, the echo pin of the ultrasonic ranging module outputs a high level to the pb6 pin of the main control chip. The duration of high level is the time from emission to return. The circuit connection diagram of ultrasonic ranging module is shown in Figure 4.

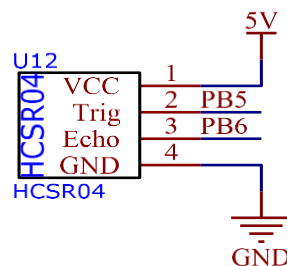


Figure 4. Circuit connection diagram of ultrasonic ranging module

## 4.3. Temperature and humidity detection module

The temperature and humidity sensor module of the intelligent trash can is used to detect whether the temperature and humidity in the trash can are normal. The auxiliary smoke sensor module and flame detection module jointly detect whether the trash can is in a normal working environment. DHT11 is selected as the temperature and humidity detection module of intelligent trash can. DHT11 digital temperature and humidity sensor integrates temperature measurement and humidity measurement. The advantage is that it contains a calibrated digital signal output. The humidity accuracy is  $\pm 5\%$  RH, the temperature accuracy is  $\pm 2^\circ\text{C}$ , the humidity range is 20-90% RH, and the temperature range is  $0 \sim 50^\circ\text{C}$ . It is a single bus protocol [4], with only one data port. In this design, the data pin is connected to the pb0 pin of the main control chip, and the circuit connection diagram of temperature and humidity DHT11 module is shown in Figure 5.

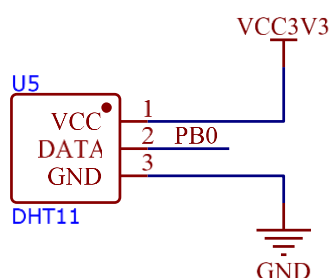


Figure 5. Circuit connection diagram of temperature and humidity DHT11 module

#### 4.4. Smoke sensor module

The smoke sensor of the intelligent trash can monitors the combustible gas in the trash can in real time and transmits it to the upper computer. When the combustible gas in the dustbin reaches the threshold, the upper computer sends an alarm to remind the staff to deal with it in time to avoid fire. The smoke detection module selects mq-2. Mq-2 smoke sensor measures liquefied gas, natural gas and city gas. Mq-2 smoke sensor has the advantages of long service life, long-term stability and reliability. The disadvantage is that it must be heated for about 20s before use, otherwise the output resistance and voltage are inaccurate, and the range of combustible gas and smoke can be detected is 300 ~ 10000ppm.

Mq-2 has two signal outputs, analog output and digital output. Do port is a digital interface and AO port is an analog interface. When the gas concentration does not exceed the set threshold, the do port outputs a low level, and the Ao voltage is basically about 0V. When the gas concentration exceeds the set threshold, the do outputs a high level, and the Ao output voltage will slowly increase with the gas concentration. In order to obtain more accurate digital, the analog signal output is connected to PA0, and the circuit connection diagram of smoke detection module mq-2 is shown in Figure 6.

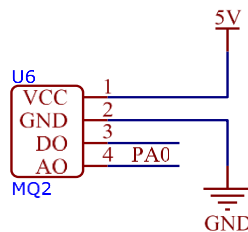


Figure 6. Smoke detection module mq-2 circuit connection diagram

#### 4.5. Flame detection module

The intelligent trash can flame detection module monitors whether there is an open fire in the trash can in real time. If there is an open fire, the upper computer will send an alarm to remind the staff to deal with it in time, so as to avoid the expansion of the fire and fire. The flame detection module selects a special infrared detection module, which can detect infrared light with a wavelength of 700nm ~ 1000nm, and the detection angle is 60°. When the infrared light wavelength is near 880nm, its sensitivity reaches the maximum. Sensitivity adjustable (blue digital potentiometer adjustment). The signal is clean, the waveform is good, and the driving capacity is strong [5]. It exceeds 15mA. It is equipped with an adjustable precision potentiometer to adjust the sensitivity, and the working voltage is 3.3V-5V.

The flame detection module has two output interfaces. Like the smoke sensor, do digital switching output and AO analog voltage output. Here, in order to facilitate the observation of whether it is on fire, do digital switching value output is selected, and its sensitivity can be adjusted through the blue digital potentiometer. When the do port outputs low level, the sensor detects flame, and when the do port outputs high level, no flame is detected. The circuit connection diagram of flame detection module is shown in Figure 7.

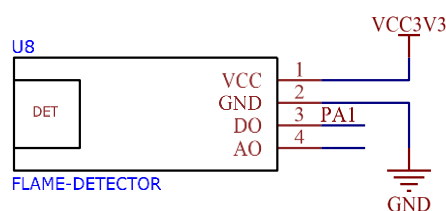


Figure 7. Circuit connection diagram of flame detection module

#### 4.6. Dial switch module

The dial switch module in the intelligent trash can is used to set the ID number of the intelligent trash can, and the upper computer communicates one by one according to the ID address. The model selected by the dial switch is dip-4p. The dial switch is used to set the ID number of the intelligent trash can in the intelligent trash can circuit. Dip-4p can set up to 16 ID numbers. The circuit connection diagram of the dial switch module is shown in Figure 8.

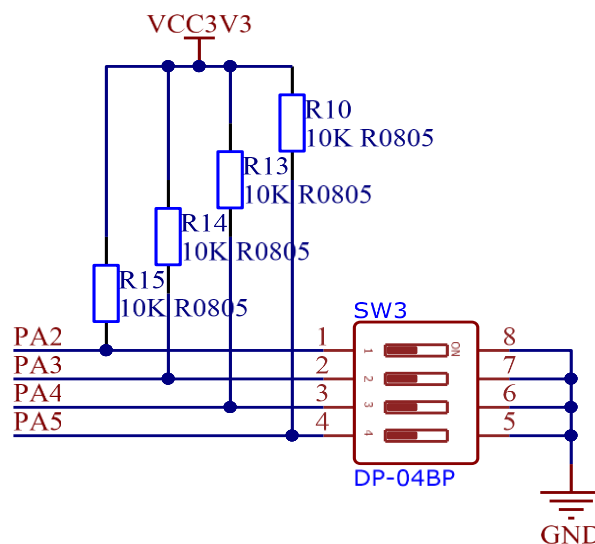


Figure 8. Circuit connection diagram of dial switch module

#### 4.7. Voice recognition control module

The function of the intelligent trash can voice recognition control module is that the user can say what garbage he throws. After the microphone receives it, the voice recognition module will recognize it. After recognition, it will tell the user the classification of the garbage through the speaker, and then open the corresponding trash can. The voice recognition module adopts speaker independent voice recognition technology. This technology has no special requirements for voice recognition, does not limit the gender and age of the speaker, and can recognize Chinese Putonghua, local dialect, foreign language, etc. The voice recognition chip used in the voice recognition module is ld3320. It can basically achieve complete recognition under 30dB environmental noise, and can maintain a recognition rate of more than 90% in the noisy environment of 30dB ~ 50dB sound, with good anti noise performance; The recognition depth can reach 32 layers, and up to 1600 short sentences can be recognized under 32 layers. Voice can be quickly downloaded by IDE software. The recognition speed is fast. The module can complete the recognition 0.5s after the end of the voice command. It can communicate with MCU through TTL level standard. There are 8 IO interfaces on board, the status is programmable, the IO port action can be triggered by the voice recognition result, and the motor drive module can be directly controlled.

The motor drive module mainly controls the opening and closing of the garbage can cover to avoid manual contact with the garbage can cover. The model selected for the motor drive module is L298N. IO1 ~ 4 in the motor drive module are the enabling pins of channel A and channel B of the drive module. When ENA/B is set to low level, there is no voltage at the corresponding output port, and the motor will not rotate; When the high level is set, and the two logic inputs are different, the motor can rotate; When the two logic inputs are at the same level, the motor stops rotating. The circuit connection diagram of voice recognition control module is shown in Figure 9.

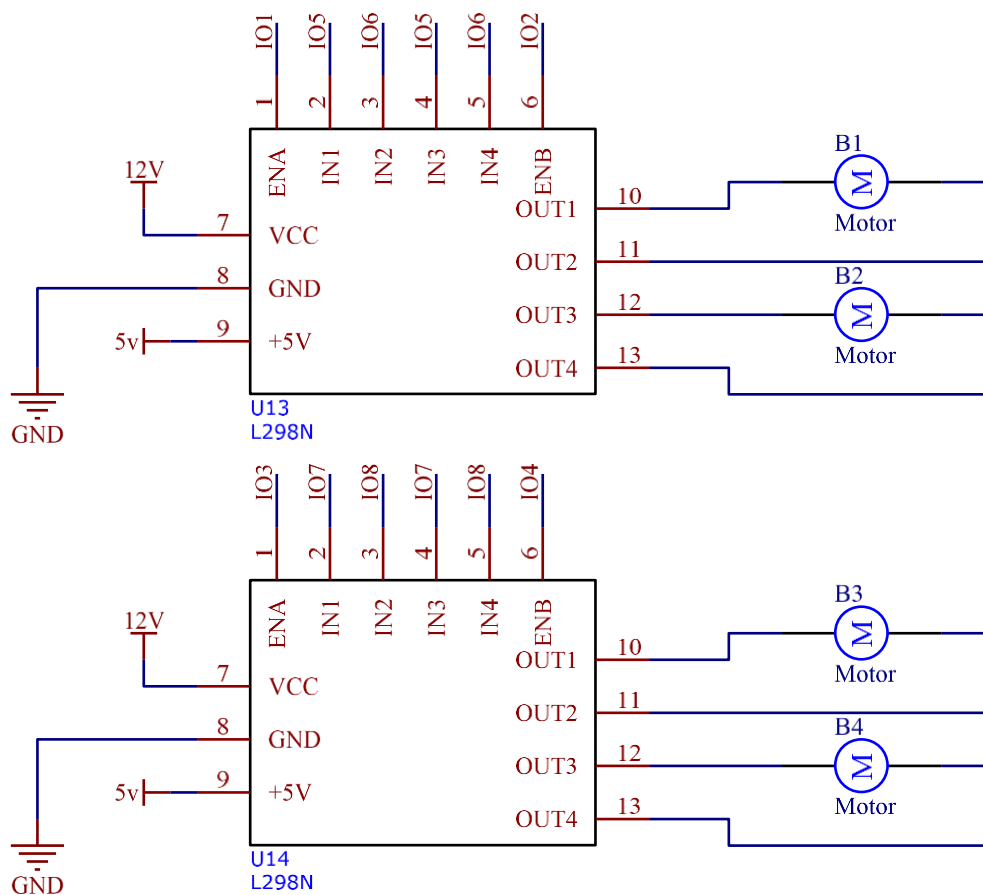


Figure 9. Voice recognition control module circuit connection diagram

## 5. Software Design

### 5.1. Embedded software design

The intelligent trash can mainly has two functions: one is to collect the information of the trash can and transmit it to the host computer software; the other is to control the opening and closing of the trash can through voice, so as to facilitate the classified storage of all kinds of garbage. After the intelligent trash can is powered on, it is initialized first, and then the ultrasonic ranging module data, temperature and humidity detection module data, smoke detection module data, flame detection module data and dial switch status are obtained to generate the ID number of the intelligent trash can. Then, all the data are combined and transmitted to the upper computer through the wireless transmission module, And judge whether the data is sent successfully. If it is sent successfully, restart the detection of intelligent trash can environment information. If it fails, resend it. The flow chart of intelligent trash can program is shown in Figure 10.

The voice control trash can opening and closing program is an interrupt subroutine of the intelligent trash can. When the voice recognition module detects "garbage classification", it enters the interrupt subroutine and continues to wait for the user's voice input. When the user says the name of the garbage to be classified, the voice recognition module recognizes the voice and judges the garbage type, If it is recyclable waste, open the recyclable trash can; if it is other waste, open other trash cans; if it is kitchen waste, open the kitchen waste trash can; if it is harmful waste, open the harmful trash can. If it does not belong to any kind, prompt to re-enter the voice command, open each trash can for 10 seconds, close it, and then return to the main program. The flow chart of voice control trash can subroutine is shown in Figure 11.

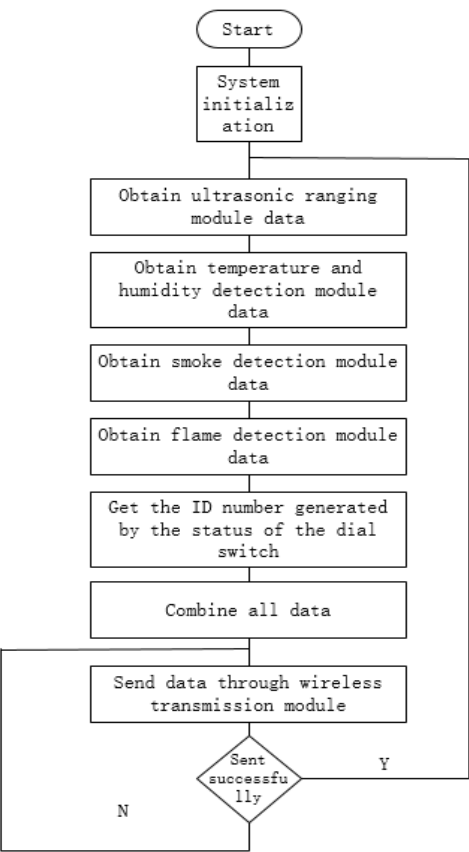


Figure 10. Flow chart of intelligent trash can program

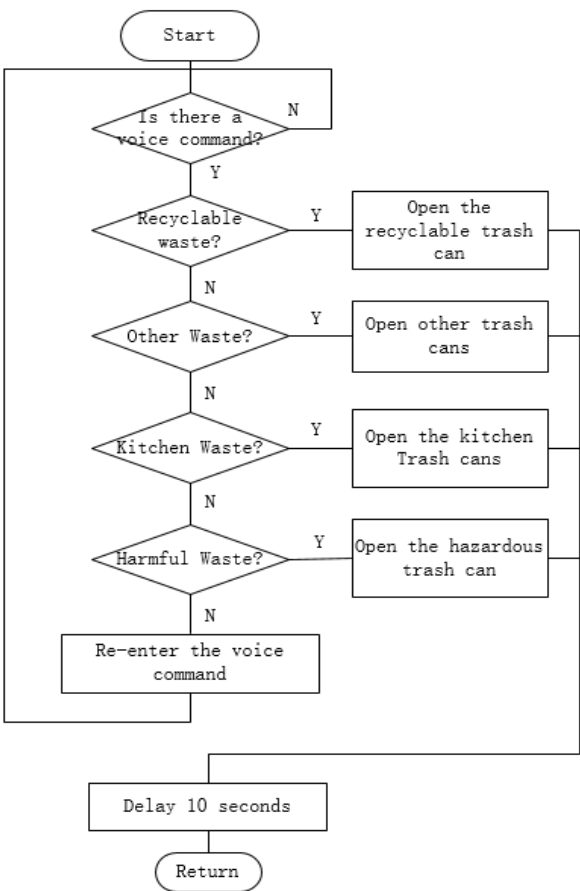


Figure 11. Voice control trash can subroutine flow chart

## 5.2. PC software design

The upper computer software is divided into four parts: software login, data display, threshold control alarm and database. Software login is to ensure the confidentiality of data. Data display is to receive and process the data transmitted from the intelligent trash can, and display them in the upper computer interface according to the serial number of the trash can, which is convenient for managers to view intuitively. Threshold control alarm: when the remaining capacity in the trash can reaches the set standard, the upper computer sends an alarm signal to remind the cleaning personnel to clean. When the temperature and humidity sensor, flame sensor and other sensors detect that the environmental information of the intelligent trash can is abnormal, an abnormal alarm will be issued to remind the cleaning personnel to deal with it in time. The database is mainly used to store the intelligent trash can data received by the upper computer. Firstly, for convenience of viewing, and secondly, through the data, several more trash cans can be placed in the place where the trash can easily overflow, so as to keep clean and improve efficiency. The functional structure of the upper computer software is shown in Figure 12.

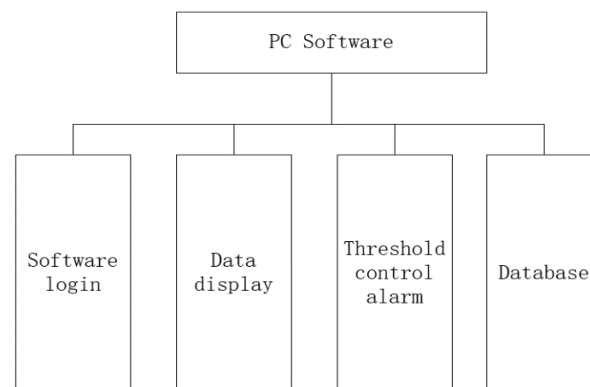


Figure 12. Function structure diagram of upper computer software

After logging in, the user directly enters the main interface, which displays the tree-like dustbin information, garbage proportion, connection to hardware and emergency events respectively. The data received by the upper computer software is processed by the program and displayed in the tree-like trash can information, in which the garbage proportion data will be intuitively displayed in the garbage proportion of the main interface. Click one button to query, and you can directly obtain the full dustbin serial number or the fire dustbin serial number in the emergency alarm.

## 6. Conclusion

At present, the concept of garbage classification is weak and the distribution of garbage cans is uneven, which makes it difficult to implement the garbage classification policy. This paper designs an intelligent garbage can system based on the Internet of things. The intelligent trash can classify the garbage thrown by the user through voice recognition and open the corresponding trash can. The residual capacity, temperature and humidity, whether it is on fire and other information of the trash cans can be detected through multiple sensors. And upload these information to the upper computer software through wireless transmission. The upper computer reminds the cleaning personnel to clean up in time by processing and saving the data sent by the intelligent trash can.

The intelligent trash can is composed of CPU module, voice recognition module, ultrasonic ranging module, flame detection module, temperature and humidity detection module, smoke

monitoring module, dial switch module, motor drive module and wireless transmission module. The voice module is used to recognize the sound, judge the type of garbage, and open the corresponding garbage can after recognition; A variety of sensor modules are used to monitor the remaining capacity of the garbage can, whether it is on fire and other environmental information; The wireless transmission module sends the data monitored by the sensor to the host computer software. The upper computer software processes and saves the received data, and displays the data on the upper computer interface to facilitate the management personnel to view. If the trash can is full or other abnormal conditions, the upper computer software will automatically alarm and remind the cleaning personnel to deal with them.

The intelligent trash can system can reduce users' learning of garbage classification knowledge, improve garbage classification efficiency, improve the utilization rate of garbage cans, reduce the workload of garbage cleaners, and put forward a feasible scheme for urban environmental protection.

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